This invention relates to new and useful improvements in devices for controlling the flow of liquids.

An object of the invention is to eliminate the objectionable noise, which occurs in controlling or restricting the flow of liquids where the pressure differential between the supply and the discharge is great with the resultant high velocity of discharge.

Further objects of the invention will appear in the course of the following specification and claims.

Since an automatic flush valve and a sink faucet provide common instances of flow controlling devices in which noise is undesirable, such apparatuses are used illustratively in this description as examples of the employment of the present invention.

In the accompanying drawing:

Figure 1 is a view partly in section and partly in elevation showing the conventional piston type of flush valve with the invention incorporated therein and the regulating stop generally used in connection therewith;

Figure 2 is a sectional view on an enlarged scale of the portion of the valve in which the invention is applied;

Figure 3 is a view similar to Figure 2, but showing a modified form of the invention, and

Figure 4 is a view in section of a conventional sink faucet in which the invention has been incorporated.

Automatic flush valves are directly connected to the water supply lines and discharge into a water closet bowl. The pressure in the supply lines varies from a minimum of 5 to 10 pounds to a maximum of 100 to 125 pounds per square inch. 40 to 60 pounds is the average pressure in the supply lines in a large majority of installations. The pressure of discharge from the valve into the bowl is relatively low, 1 to 3 pounds being sufficient for a large majority of closets. Little noise occurs in flush valves or in other valves and flow control devices when the pressure differential between the supply and discharge is less than 30 pounds. The noise increases rapidly as the pressure differential increases, so that in a majority of installations of flush valves there is a definite objectionable noise.

In the employment of automatic flush valves, it is customary to use a regulating stop thereon. The purpose of this regulating stop is to regulate the flow of the water during the full flushing period and also to shut off the water supply when repairs are being made to the flush valve itself. In such a combination, two problems of noise are involved.

The first of these is to eliminate the objectionable noise incident to the control of the flow through the regulating stop during the period of full flush when the flush valve is wide open and when there is a high pressure in the supply lines.

The second problem of noise has to do with the noise caused by the flush valve itself, during the shutting off period. During this shutting off period the flush valve itself becomes the point of maximum restriction and the controlling factor in the flow.

In our co-pending applications Serial No. 63,238 and 75,474, we have shown a regulating stop, which will quietly retard the flow during the full flushing period of the flush valve. A quiet regulating stop, however, does not reduce the noise in the final or shutting off stage of the flush valve and the present invention relates to a means whereby this objectionable noise is eliminated, so that the apparatus, as a whole, will be quiet, not only during the full flushing period, but also during the shut off period.

One of the principal causes of noise in restricting the flow of water is due to the contact of the high velocity water in the discharge or flow stream with the water already in the discharge passageway. This contact occurs in a zone of low pressure (subatmospheric) caused by pressure head being converted into velocity head at the point of maximum restriction and by the change of cross sectional area of flow thenceforth. The contact between the fast and slower moving water causes a shearing effect. At the higher velocities, a definite cavitation or void is produced, which is visible to the naked eye when the apparatus is made of glass.

We have found that the admission of a very limited amount of air at or near the point of maximum restriction or the discharge therefrom into this region of low pressure, is sufficient to eliminate the objectionable noise, otherwise occurring. This is the essence of the invention. Air, in excess of this limited amount, causes other noises as explained later. There is a great turbulence with cross currents and back currents beyond the point of maximum restriction so that the air admitted near this point is picked up by the water, churned into a state of emulsion and carried back to the point of maximum restriction, where it appears to reduce or eliminate the effect of the cavitation. The finely divided mixture of air and water is of less specific gravity and more
mobile than plain water and therefore accelerates more rapidly to the velocity of the main flow stream.

Referring to Figures 1 and 3, a conventional flush valve FV of the piston type is shown connected directly to the water supply WS through the regulating stop RS and to the closet bowl (not shown) by the discharge tube DT. Briefly stated, the flush valve FV includes a casing 2 having a bore 16 at the upper end of which is a valve seat 11. This bore 16 leads to the chamber 4 which delivers water to the tube DT and thence to the closet bowl. The valve proper is indicated at 2 and includes a piston having a seat washer 6 attached thereto which engages the valve seat 11. Depending from the piston is a retarding ring 10 which enters the bore 16 through the valve seat. Also associated with the valve 2 is the conventional auxiliary valve 14 which, when tipped by the handle H, releases the water in the upper chamber 14a. The valve assembly 2 is then raised by the pressure on its under side and permits the flow of the water from the water supply WS past the valve seat 11 through the bore 16 and the chamber 6 into the delivery tube DT. As the flushing period progresses, water flows through the bypass 14 into the chamber 14a and the piston gradually descends until its downward movement is stopped by the seat washer 5 contacting with the valve seat 11. As the lower portion of the retarding ring 10 approaches the seat 11 the flow is reduced so as to break the syphon in the trap of the bowl. It is during this period of operation that the greatest noise occurs. A definite and objectionable noise continues after the retarding ring 10 has entered the bore 16 until the valve is seated. During this period only sufficient water passes between the retarding ring 10 and the bore 16 to seal the trap in the bowl. It is these two objectionable noises, which the present invention as so eliminates, or reduces to a minimum. At any convenient place around the casing 1 of the flush valve FV and in a transverse plane below the top portion of the seat, one or more air intake ports 6 are provided through the casing. Only one air intake port is illustrated and the description will be limited thereto. If other ports are used, they will be similarly constructed and connected. By this arrangement of the air intake, which is adjacent to the valve seat and beyond the same in the direction of flow, air is admitted to the region of low pressure caused by the restriction between the valve and the valve seat. In the present embodiment of the invention the casing is provided with a cylindrical boss 12, and the air intake port is formed by drilling a hole through the boss and the casing.

The boss is externally threaded to receive a sleeve 8. Said sleeve is provided with an internal shoulder 13, and the boss has a bore in its outer end of larger diameter than the air intake port 6. A washer 20 is placed against the end of the boss and a metering disk 7 against the washer, so that, when the sleeve 8 is screwed tight, a seal is obtained between the disk and the boss. The metering disk 7 is provided with an air intake orifice 7a. The outer end of the sleeve 8 is counter-bored so as to receive a perforated plate or screen 9, and the outer edge of the sleeve is spun over the plate or screen for holding the same in place.

When the valve is wide open, the water passing seat 11 and entering the bore 16 of reduced diameter is deflected away from the walls of the bore 16 and its velocity materially increased. This produces a zone of low pressure (slightly subatmospheric) along the wall of the bore 16 for some distance below the seat 11 and in the region of the inner end of the air intake port 6. As the valve closes and the retarding ring 10 approaches the seat, the flow stream is directed still further away from the wall of the bore 16, and its velocity further increased. A zone of very low pressure is thus created along the wall of the bore 16 for a considerable distance below the seat 11 and in the region of the air intake port 6. The differential in pressure at the under ends of the air intake port 6 is sufficient to force air through the air intake port 6 into the bore 16, even when a high back pressure is maintained at the discharge end of the valve. It is during this period of operation that the greatest noise occurs, and the objectionable noise is practically wholly eliminated by the admission of a limited amount of air. As the retarding ring 10 further enters the bore 16, the quantity of flow is so reduced and the velocity is so high, that the subatmospheric pressure continues to exist along the wall of the bore 16 and air continues to force through the air intake port 6 up to the seating of the washer 5 against the valve seat 11.

The size of the port 6 is not of material importance, as the intake of air is controlled by the orifice 7a in the metering disk 7. A diameter of 1/16" to 1/8" for the air intake port 6 has been found generally satisfactory.

Considerable leeway in the dimensioning of the orifice 7a in the metering disk 7 is permissible, and it varies according to the design and proportion of the flush valve used in connection therewith and with the location of the air intake port 6 with respect to the seat 11. Generally speaking, an orifice in a thin metering disk 0.015" to 0.030" in diameter will supply ample air to eliminate objectionable noise during the shut off of any conventional flush valve. If the orifice is too large or the amount of air not limited, objectionable noise is caused by the air entering and passing through the air intake port and also by the mixed air and water as it flows through the discharge tube, the rim of the bowl, the rim holes and into the bowl itself. Therefore, unless the amount of air is controlled, the noise is not accomplished in reducing the noise. The size or dimension of the metering orifice 7a, which controls the quantity of air admitted, is determined for the specific application. It is dimensioned to admit sufficient air to quiet the noise incident to retardation of the flow stream and insufficient air to cause other noises therefrom.

The size of the opening in the perforated plate or screen 9 are smaller than the orifice 7a in the metering disk 7, so as to prevent clogging of the metering orifice. However, the combined area of the openings in the perforated plate or screen 9 are sufficient so that the size of the orifice 7a in the metering disk is the controlling factor in determining the supply of air through the port 6.

Considerable latitude in the location of the air intake port 6 relative to the valve is possible. The exact location for best results depends upon the particular design and proportions of the flushing valve with which it is associated. In the form shown in Fig. 1, the bore 16 is of substantial length. In such cases the best results are obtained when the air intake port is placed so that the inner terminus is close to and slightly beyond, in the direction of flow, the lower...
end of the retarding ring 10 when the valve is closed. Such a point is in the zone of low pressure (subatmospheric) during the entire period of operation of the valve and the chance of any water passing out of the air intake port is reduced. If the bore 16 is relatively short as is the preferred form of the invention includes as short a length of bore 16 as practical, an appreciable larger diameter in the chamber 4 than in the bore 16 and the air intake port located immediately below the bottom of the bore 16.

It is understood, therefore, that the invention is not limited to the location of the air intake port as illustrated, but it may be placed closer to, or further from the valve seat as long as the interior terminus is well within the zone of reduced pressure, caused by the flow between the seat and the valve. The position is determined by a suitable valve to which it is applied, and so that when applied, it will eliminate the objectionable noise referred to.

The arrangement of the metering disk, sleeve and perforated plate or screen, as described above, has been found effective, simple and inexpensive. It will be understood, however, that this arrangement may be greatly modified, and any suitable device for controlling the flow of air through the air intake port in the casing may be employed, or such device entirely eliminated if the port itself is properly proportioned so as to admit the right amount of air to eliminate all the objectionable noises. The proportioning of the port itself to the exact size presents manufacturing difficulties, and without the filter or guard such a small port is liable to clog.

Radially disposed wing members 24 are sometimes used in connection with flush valves, said members contacting with the wall of the bore 16 for guiding the valve in its movements. When such wing members are present, they will extend as illustrated in Figure 1, so as not to extend up to the retarding ring 10. In other words, there is a passageway all the way around the valve directly beneath the ring 10. In this way, the air entering through the air intake port 6 can move around the entire circumference of the bore 16 and is not confined to one quadrant as would be the case if the wing members extended all the way to the retarding ring 10.

In a certain type of closet bowl, a relatively high pressure is required for satisfactory operation. In such cases, a pressure slightly subatmospheric may exist along the wall of the bore 16 at the inner end of the air intake port 6 when the valve is wide open.

To prevent the escape of water from the air intake port, under these circumstances, there is shown a modified form of the invention in Figure 3. In this case, a light spring 21, a ball 22 and a seat member 23 to cooperate with the ball is associated with the air intake port 6. This check valve is so disposed as to prevent the water from passing out through the air intake port, while it permits the free flow of air when the valve is open.

It is apparent that the invention is capable of wide application in the eliminating of objectionable noise which occurs in restricting the flow of liquids at high velocities. To make the scope of the invention clearer, the application of the same has been shown as applied to the conventional sink faucet in Figure 4. In connection with the flushing valve, the air is admitted through the casing to the outer side of the annular sheet of water flowing between the valve seat and the valve. In a sink faucet, the air is admitted through the valve to the interior of such annular sheet.

Referring to Fig. 4, the valve stem 30 is drilled as at 39 from the seat end to a point below the bottom of the handle 31 and is counterbored as at 32 to receive the split end 33 of the seat washer 34. The depth of this counterbore is such that a space or passageway 35 is always maintained between the back and bottom of the seat washer 34 and the lower end of the air intake port 30. At a point slightly below the bottom of the handle 31, a metering orifice 36 is provided to connect with the axial passageway 35 in the stem. The handle is counterbored at 37 so as to provide a protection for the metering orifice 35. The lower end of the stem is provided with a casing ring 38. The inside diameter of the casing ring 38 is slightly larger than the outside diameter of the seat washer holder 34 leaving the space 40 therebetween. The lower end of the casing ring 38 terminates slightly above the lower face of the seat washer 41.

When the valve is opened by moving the stem assembly away from the seat 42, the water flows between the seat washer 41 and the seat 42 as shown by the arrows. The velocity of the water at this point is high and the pressure low—in fact sub-atmospheric so that as the flow stream passes off the seat washer 14, air is drawn in through the channel formed by the spaces 40, 35, 39 and 36. The admission of a limited amount of air at any point close to the maximum restriction of the seat and downward thereof eliminates the objectionable noises caused by this throttling and is the essence of the invention.

The construction and operation of the sink faucet shown above is typical of other plumbing fixtures such as basin and bath faucets, etc., where the elimination of noise is most desirable and in which the present invention can be readily incorporated.

By properly proportioning the parts of the valve and carefully locating the entrance of the air port with respect to the seat, a sub-atmospheric pressure at such entrance point and consequent sucking in of air through the air port at all times can be obtained even though there is a substantial back pressure to the discharge of the valve in such case as shower heads, for example.

It is obvious from the above that the invention has a wide range of application and is not limited to the specific illustrated embodiment thereof. It is also obvious that the arrangement of the parts and the details of construction can be widely varied without departing from the spirit of the invention as set forth in the appended claims.

Having thus described the invention, what we claim as new and desire to secure by Letters Patent, is—
1. In a device for retarding the flow of liquids under pressure, the combination of a valve body having a valve seat therein, a valve cooperating with said seat for controlling the flow of liquid through said valve body, and means for reducing the noise incident to the retardation of the flow when the valve and seat form a restricting passage, said means including a metering orifice arranged to admit air to the region of low pressure caused by the restriction between the valve and the valve seat, said passage having an orifice with a cross-sectional area not exceeding 0.0012 square inch.

2. In a device for retarding the flow of liquids under pressure, the combination of a valve body having a valve seat therein, a valve cooperating with said seat for controlling the flow of liquid through said valve body, and means for reducing the noise incident to the retardation of the flow when the valve and seat form a restricting passage, said valve body having a passage arranged to admit air at the region of low pressure caused by the restriction between the valve and the valve seat, a portion of said passage being dimensioned so as to admit air in sufficient quantity to reduce the noise incident to retardation of the flow and in insufficient quantity to create objectionable noises caused by the admitted air.

3. In a device for retarding the flow of liquids under pressure, the combination of a valve body having a valve seat therein, a valve cooperating with said seat for controlling the flow of liquid through said valve body, and means for reducing the noise incident to the retardation of the flow when the valve and seat form a restricting passage, said valve body having a passage arranged to admit air at the region of low pressure caused by the restriction between the valve and the valve seat, said passage having an orifice with a cross-sectional area not exceeding 0.0012 square inch.

4. In a device for retarding the flow of liquids under pressure, the combination of a valve body having a valve seat therein, a valve cooperating with said seat for controlling the flow of liquid through said valve body, a lever beyond the seat in the direction of flow for actuating the valve, and means for reducing the noise incident to the retardation of flow when the valve and seat form a restricting passage, said means including a metering orifice arranged to admit air through the valve body at a point between the seat and the operating lever, said orifice being dimensioned so as to admit a sufficient quantity of air to reduce the noise incident to the retardation of the flow and an insufficient quantity of air to create objectionable noises caused by the admitted air.

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